INVESTIGATION INTO THE EFFECTS OF EGG SHELLS POWDER (ESP) AND GROUNDNUT HUSK ASH (GHA) ON THE PROPERTIES OF CONCRETE

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ABSTRACT

This study presents an investigation into the improvement of strength properties of concrete using egg shell powder (ESP) and groundnut husk ash (GHA) as additives so as to reduce its high cost and find alternative disposal method for agricultural waste. A standard consistency test was carried out on the egg shell powder and groundnut husk ash. A prescribed concrete mix ratio of 1:2:4 concrete cubes (150mm by 150mm) and water-cement ratio of 0.6 were casted. A total of One hundred and forty four (144) cubes were cast and cured for 3, 7 and 28 days and compressive strength subsequently determined in comparison with the relevant specifications. Consistency test on the cement paste at the various concentrations exhibited an increase in the setting time as the concentration increases with the highest value recorded at 5% egg shell powder and groundnut husk ash concentration as 219 minutes for the initial setting time and 275 minutes for the final setting time as against the control specimen of 159 minutes and 234 minutes for both initial and final setting times respectively. The results of the investigations showed that GHA was predominantly of Silicon oxide (56.73%) and a combined SiO_2, Al_2O_3 and Fe_2O_3 content of 66.75%; and the result of the investigations showed that ESP was predominantly of Calcium oxide (52.75%) and a combined SiO_2, Al_2O_3 and Fe_2O_3 content of 3.86%. The addition of GHA and ESP in concrete showed slight different in compressive strength with increase in GHA and ESP additive up to 5% and high decrease in compressive strength with further increase in GHA and ESP content. The 28 days compressive strength of the concrete cubes; compared with that of the control; showed a slight increase. Thus the use of GHA and ESP as partial replacement of cement will provide an economic use of by-product and consequently produce a cheaper concrete construction without comprising its strength.

Keywords: Additive, Concrete, Egg shell powder, Groundnut Husk Ash Compressive strength.

1.0 Introduction

Concrete is an essential material which is widely used in the construction of infrastructure such as buildings, bridges, highways, dams, and many other facilities. To provide the needs and changes, large amounts of materials are needed for the construction of buildings, houses, roads and infrastructures required for decent living (soosan et, al. 2013); The production of ordinary Portland cement produces approximately 7% of the total greenhouse gas emitted to the atmosphere. Egg shells powder and groundnut husk ash has been considered as a waste material and has generally been disposed of by dumping or burning, although some has been used for other purposed. The most commonly used coarse and fine aggregates are scarce due to its greater demand and unsustainable. Today, there exist greater need to search for alternatives to natural aggregates alternatives in concrete to forestall problem of ecological instability from excessive mining of natural aggregates (Alengaram et, al. 2008);Osei and Jackson, 2012; Eldhose and Soosan, 2014). Therefore, finding alternatives to natural available materials is vital for successful and sustainable infrastructural development in any community.

Researchers round the world had explored alternative materials, majorly wastes that could be used in this regard. Ndoke (2006) investigated suitability of palm kernel shells as partial replacement for coarse aggregates in asphaltic concrete. Olanipekun *et, al.* (2006) compared concrete made with coconut shells and palm kernel shells

as replacement for coarse aggregates. Olutoge (2010) investigated the suitability of saw dust and palm kernel shells as replacement for fine and coarse aggregate in the production of reinforced concrete slabs.

Resource reutilization of egg shell powder and groundnut husk ash had equally been considered as possible alternatives to cement (binder). Siddique *et, al.* (2004) found egg shells powder and groundnut husk ash concrete useful in road foundations, bridge barriers and places where desired deformability to toughness was more important than strength. The authors discovered that egg shells powder and groundnut husk ash concrete possessed reversible elasticity properties that rendered it fit for use as material with tolerable damping properties for minimizing structural vibration under impact effects. Najmi and Hall (2010) observed that rubber incorporated mixes produced very low unit weight mixes with high air contents. The authors discovered that egg shells powder and groundnut husk powder addition in concrete improved not only dynamic loading behaviour but also impact, vibration and absorption characteristics.

Gintautas *et, al.* (2007) used egg shells powder and groundnut husk ash as fine aggregate replacement. Sgobba *et, al.* (2010) submitted that the resulting powder provided final products with good mechanical properties and presented effective and inexpensive ways of recycling the discarded egg shells powder and groundnut husk ash,

replacing partially to totally natural aggregates. Huang *et al.* (2014) reported that the egg shells powder and groundnut husk ash size has an important effect on the strength of concrete. With the same amount of egg shell and groundnut husk used, reducing powder size significantly increases the strength of concrete.

Lijuan*et* (2014) investigated the influence of egg shells powder and groundnut husk ash content and particle size on the mechanical properties of concrete. The authors observed that higher egg shells and groundnut husk content and powder particle size decreased the compressive strength and elastic modulus of concrete, while the ultimate strain of PRC increased as concrete content increased and particle size powder.

Concrete is a material obtained by mixing of cement, sand and gravel, or other aggregates with water. It can be poured into any desired shape and dimension of structure through a chemical reaction known as hydration the paste hardens and gain strength to form concrete. As long as the concrete kept cured it continues to gain the strength because the process of hydration continues in the presence of water. Mixed water in concrete can be utilized for hydration, if it is secured by curing. Generally concrete gains most of its strength within first 28 days but a slower process of hydration continues for many years. Concrete is a brittle material and is very strong in compression but weak. The characteristic of aggregates play the substantial role in the

fresh and hardened properties of concrete as it couples about 50 % to 80 % of total concrete volume. It is commonly accepted that the properties of aggregates use in normal strength concrete (NSC) have great influence on the mechanical properties and durability (alade *et al* 2015)

2.0 Materials and Methods

2.1 Materials

Egg shells and groundnuts husk ash was sourced within Niger State. The laboratory analysis was carried out at structural laboratory of Civil Engineering Department, Federal Polytechnic Bida Niger state. Silt content and practice size analysis was carried out on the sand sample to ensure its suitability for concrete. The Dangote cement brand of ordinary Portland cement was used in this investigation. The groundnut husk ash (GHA) was obtained by burning the groundnut husk to ash and under a controlled temperature of about 600^{o}c in a kiln and controlling the firing at that temperature for about two (2) hours and the ash was allowed to cool. After cooling, the resultant GHA grounded and sieved using BS sieve No.200 (75μm) sieves. The resultant eggshells were dried naturally and subsequently grounded in to a powder form, and the powder was sieved using BS sieve No.200 (75μm) sieves.

2.2 Methods

Six mixes were used for the determination of consistency and setting times of cement paste containing ESP and GHA in accordance with BS EN 196, Part 3, (1995). CE-00 is the control mix and CE-01, CE-02, CE-03 CE-04 and CE-05 are mixes containing GHA, ESP and 50% GHA and 50% ESP replacement of 5, 10, 20, 30 and 40%, respectively. Average of three readings was recorded. Concrete mix of 1:2:4 and water-cement ratio of 0.6 was used to assess the effect of ESP and GHA as additive in concrete. A total of one hundred and forty four (144 Nos) of 150 mm cube specimens were cast and cured in water for 3, 7, and 28 days. At the end of every curing time, compressive strength was determined in accordance with BS EN 12390, Part 3 (2009).

3.0 Discussion of Results

3.1 Chemical Properties of GHA and ESP

The oxide composition of groundnut husk ash (GHA) is presented in Table 1 and it indicated that the predominant oxide is Silicon oxide (20.03%) and a combined SiO_2, Al_2O_3 and Fe_2O_3 content of 27.11%; The oxide composition of egg shell powder (ESP) is presented in Table 1 and it indicated that the predominant oxide is of Calcium oxide (52.75%) and a combined SiO_2, Al_2O_3 and Fe_2O_3 content of 3.86%. This shows that ESP is cementitious and may combined with CPA containing high silicon, iron and aluminium oxide in a hydrated mix and due to pozzolanic reactions yield final products that are similar to

those obtained from cement hydration process. Nuruddeen, (2012) reported that, the SO_3 content affect the strength of mortar and concrete specimens to some degree. The higher the SO_3 content, the higher the resultant strength.

Table 4.2: oxide Composition of OPC (Dangote) GHA and ESP

	oxide Value (%)										
	SiO_2	**Fe_2O_3**	**Al_2O_3**	**CaO**	**K_2O**	**SO_3**	**MgO**	**Na_2O**	**MnO**	**ZnO**	**LOI**
Cement	18.1	4.82	3.10	68.37	0.35	1.82	1.48	0.32	0.03	0.00	1.27
GHA	20.03	4.03	2..04	13.19	38.93	1.30	1.58	0.41	0.78	0.05	8.74
ESP	0.09	0.06	0.07	52.75	0.31	1.54	0.73	0.00	0.00	0.00	42.16

3.2 Physical Properties of Concrete Constituent Materials

The physical properties of the constituent materials are shown in Table 1, The particle size distribution curve indicates that the sand used was classified as zone 2 based on British Standard classification BS 882, Part 2, (1992).

Table 4.2: Physical properties of OPC (3X Dangote cement)

Property	**Value**		
	OPC	**GHA**	**ESP**
Specific gravity	3.14	2.17	1.29
Fineness (% passing 90µm sieve)	94	100	100
Loss on Ignition	1.3	8.74	42.16
Colour	Dark grey	Brownish grey	Whitish

3.3 Compressive strength of GHA, ESP and GHA/ESP – Concrete

The result of compressive strength of cement–GHA, ESP and GHA/ESP blended concrete is shown in Figure 3, 4 and 5, and it was observed that the compressive strength irrespective of the amount of GHA, ESP and GHA/ESP in the mixture, increase with curing age and deceased with increase in the content of GHA, ESP and GHA/ESP. It was observed that the GHA quantity of 5 and 10% are at the range where concrete work is most appropriate. Above this value (quantity of GHA) the strength of the concrete will be too low as it had dropped by almost half of the strength of the control, this is logical owing the reduction in OPC content in the mix and increase in the content of GHA.

The 28 days compressive strength of ESP-cement concrete with ESP content of up to 5% cement replacement by weight were almost the same strength with the control concrete. This may be due to the formation of uniform C-S-H gel and less void. The continue decrease in compressive strength after 5% replacement may be due to the present amount of ESP in the cement concrete due to more void and lack of formation of C-S-H gel take place. The decrease in strength with increase in ESP replacement could be due to the reaction mechanism of ESP, which is divided between physical and chemical aspects (Ding Zhu, 2002 and Elinwa and Ejeh 2004).

The increase in strength with age of curing is due to hydration of cement and pozzolanic reaction of GHA/ESP. The pozzolanic reaction

is a simple acid-base reaction between calcium hydroxide and silicic acid, and the pozzolanic reaction is commonly described as a reaction between $Ca(OH)_2$ released from the hydration of cement and SiO_2 in the presence of water to produce calcium silicate hydrate, (Hosseini *et al.* 2011).

The decrease in strength with increase in CPA/ESP replacement could be due to slower strength development from the pozzolanic reaction which is responsible for the reduction in strength. Though, higher compressive strength of mix containing GHA/ESP up to 5% replacement are almost the same with the control mix at 28 days curing and this is due to slower of pozzolanic reaction where dilution effect is not significant and the secondary C-S-H compliment the strength from the hydration products.

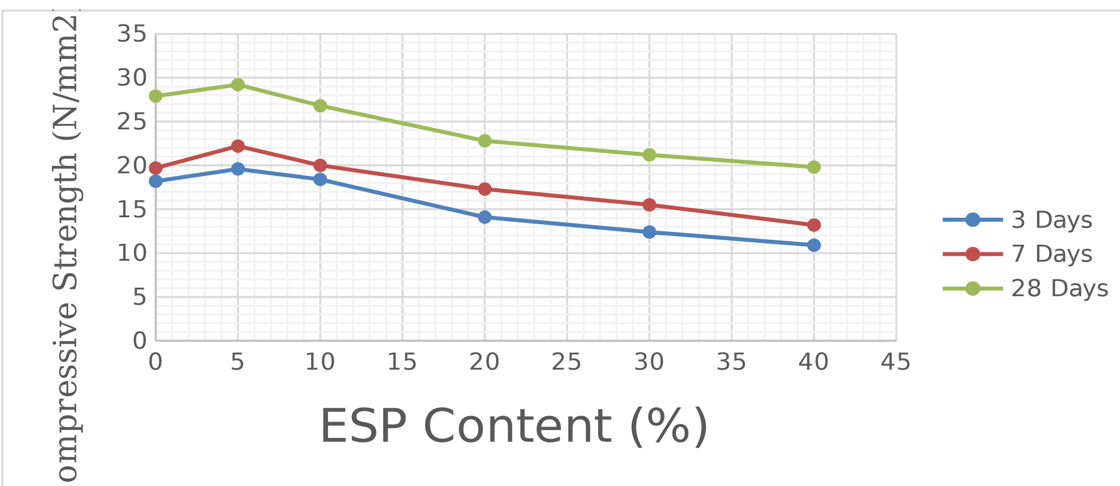

Figure 3: Compressive strength of ESP - Cement Concrete

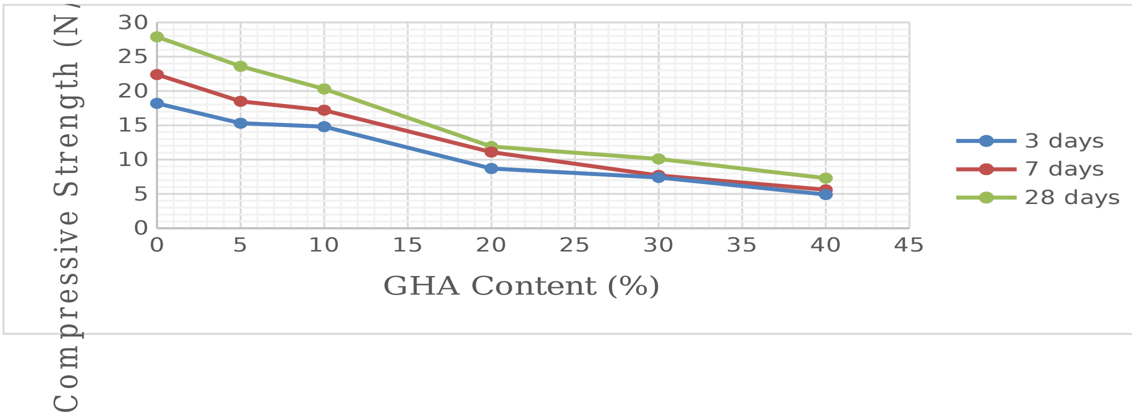

Figure 4: Compressive strength of GHA - Cement Concrete

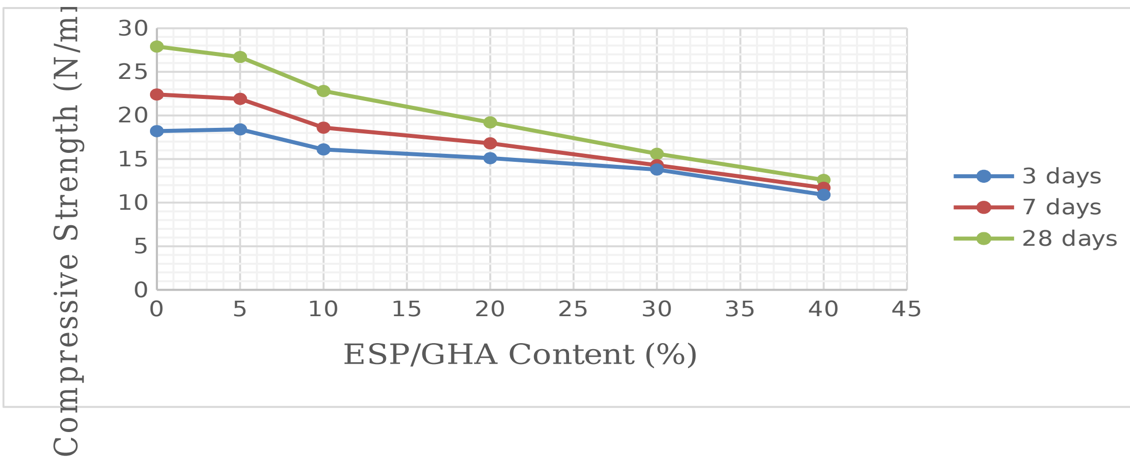

Figure 5: Compressive strength of GHA/ESP - Cement Concrete

4.0 Conclusion

Based on the study conducted on GHA, ESP and GHA/ESP Concrete, the following conclusions and recommendations can be drawn.

i. The compressive strength of GHA-Concrete decreased with increase in GHA content..

ii. The use of GHA increased the water absorption of concrete with increase in CPA content.

iii. The 28 days compressive strength of ESP-cement concrete at 5% replacement by weight is higher than the strength of the control

concrete. By replacing cement with ESP above 5%, reduction in compressive strength was observed at the age of 28 days.

iv. With the increase in the percentage of GHA/ESP, the compressive strength of concrete at 5% and 10% is almost the same with the compressive strength of the control concrete.

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